MOTION BLUR COMPENSATION THROUGH DISPLAY ACTUATION

CROSS-REFERENCE TO RELATED APPLICATION

This Application claims the benefit of U.S. Provisional Application Ser. No. 62/727,093 filed Sep. 5, 2018, which is incorporated herein in its entirety.

TECHNICAL FIELD

The present disclosure generally relates to systems, methods, and devices for presenting content on a display of an electronic device, and in particular, to compensating for motion blur while presenting content on a display of an electronic device through display actuation.

BACKGROUND

The human visual system integrates information across time. Consequently, optical energy that moves across a person's retina faster than the retina can react to such stimulus would be perceived as blurred or smeared. This phenomenon is referred to as motion blur or retinal smear. In the context of display devices, motion blur may arise due to a frame rate of content presented on a display, a response time of pixels comprising the display, or when objects within the content transition quickly across the display. When a display device is attached to a user (e.g., a head-mounted device), motion blur may be associated with inter-frame movement of the display device itself. One existing technique of compensating for motion blur includes reducing a duty cycle of the display (pixel persistence), which reduces the amount of time that activated pixels remain illuminated after each frame update. Yet, any reduction in the effects of motion blur that is achieved by reducing the display duty cycle comes with tradeoff costs. One such tradeoff cost is that a perceived brightness of the display device would also be reduced because of the manner in which the human visual system processes visual stimuli. Thus, it may be desirable to provide a means of compensating for motion blur while presenting content on a display of an electronic device that eliminates or reduces such tradeoff costs.

SUMMARY

Various implementations disclosed herein include devices, systems, and methods of compensating for motion blur while presenting content on a display of an electronic device through display actuation. In one implementation, a method involves detecting movement of the electronic device using a sensor of the electronic device while presenting content on a display of the electronic device. An inter-frame movement of the electronic device is determined based on the movement of the electronic device. The display is moved using an actuator of the electronic device that is coupled to the display such that movement of the display opposes the inter-frame movement of the electronic device.

In another implementation, an electronic device includes a display, a processor, and an actuator device that is coupled to the display. The processor is configured to determine a translation vector using data corresponding to movement of the electronic device. The translation vector defines inter-frame movement of a pixel of the display. The actuator device is configured to move the display based on the translation vector such that movement of the display opposes the movement of the electronic device.

In another implementation, an electronic device includes a sensor, a processor, and an actuator adapted to couple with a display. The sensor is configured to detect movement of the electronic device. The processor is configured to determine a translation vector based on the movement of the electronic device. The translation vector defines a displacement of the electronic device in a ground reference frame between a first time and a second time subsequent to the first time. The actuator is configured to impart a motive force based on the translation vector such that a movement associated with the motive force opposes the movement of the electronic device.

In accordance with some implementations, a device includes one or more processors, a non-transitory memory, and one or more programs; the one or more programs are stored in the non-transitory memory and configured to be executed by the one or more processors and the one or more programs include instructions for performing or causing performance of any of the methods described herein. In accordance with some implementations, a non-transitory computer readable storage medium has stored therein instructions, which, when executed by one or more processors of a device, cause the device to perform or cause performance of any of the methods described herein. In accordance with some implementations, a device includes: one or more processors, a non-transitory memory, and means for performing or causing performance of any of the methods described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the present disclosure can be understood by those of ordinary skill in the art, a more detailed description may be had by reference to aspects of some illustrative implementations, some of which are shown in the accompanying drawings.

FIG. **1** is a block diagram of an example operating environment, in accordance with some implementations.

FIG. **2** illustrates a top-down view of an electronic device presenting content on a display at a first point in time, in accordance with some implementations.

FIG. **3** illustrates a top-down view of the electronic device of FIG. **2** at a second point in time, in accordance with some implementations.

FIG. **4** illustrates a top-down view of the electronic device of FIGS. **2** and **3** between the first and second points in time, in accordance with some implementations.

FIG. **5** is a space-time diagram representing a technique of compensating for motion blur due to inter-frame movement of an electronic device through modifying content frame rate, in accordance with some implementations.

FIG. **6** is a space-time diagram representing a technique of compensating for motion blur due to inter-frame movement of an electronic device through modifying display duty cycle, in accordance with some implementations.

FIG. **7** is a space-time diagram illustrating an artifact that results when missed frame updates coincide with inter-frame movement of an electronic device, in accordance with some implementations.

FIG. **8** is a flow-chart illustrating an example of a method of compensating for motion blur while presenting content on a display of an electronic device through display actuation.

FIG. **9** illustrates a projection of a translation vector defining inter-frame movement of an electronic device, in accordance with some implementations.